# Mathematics of <br> <br> Computation 

 <br> <br> Computation}

Coden: MCMPAF
Volume 27, Number 122

Pages 221-453
April 1973

Published by the American Mathematical Society

## Editorial Committee

Eugene Isaacson, Chairman, New York University, Courant Institute of Mathematical Sciences, 251 Mercer Street, New York, New York 10012 Assistant to the Chairman: Charlotte W. John
James H. Bramble, Department of Mathematics, Cornell University, Ithaca, New York 14850
Alston S. Householder, Department of Mathematics, Ayres Hall, The University of Tennessee, Knoxville, Tennessee 37916
John W. Wrench, Jr., Naval Ship Research and Development Center, Bethesda, Maryland 20034

## Board of Associate Editors

James W. Daniel, Department of Mathematics, University of Texas at Austin, Austin, Texas 78712
Walter Gautschi, Computer Sciences Department, Purdue University, Lafayette, Indiana 47907
Heinz-Otto Kreiss, Computer Science Department, University of Uppsala, Uppsala, Sturegaten 4, Sweden
Yudell L. Luke, Department of Mathematics, University of Missouri at Kansas City, Kansas City, Missouri 64110
James N. Lyness, Argonne National Laboratory, 9700 South Cass Avenue, Argonne, Illinois 60439
Beresford Parlett, Department of Computer Science, University of California, Berkeley, California 94720
Philip Rabinowitz, Department of Applied Mathematics, The Weizmann Institute of Science, Rehovot, Israel
John R. Rice, Division of Mathematical Sciences, Purdue University, Lafayette, Indiana 47907
Daniel Shanks, Naval Ship Research and Development Center, Bethesda, Maryland 20034
Hans J. Stetter, Institut für Numerische Mathematik, Technische Hochschule Wien, Karlsplatz 13, A-1040 Wien, Austria

## Information for Subscribers

The journal is published quarterly in one volume per year, with issues numbered serially since Volume 1, Number 1. The subscription price is $\$ 24.00$. All back volumes are available. For Volumes 1-19 (1943-1965), prices are $\$ 20.00$ per volume; for Volumes 20-23 (1966-1969), \$24.00 per volume and Volumes 24-26 (1970-1972), $\$ 30.00$ per volume.

## Unpublished Mathematical Tables

The editorial office of the journal maintains a repository of Unpublished Mathematical Tables (UMT). When a table is deposited in the UMT repository a brief summary of its contents is published in the section Reviews and Descriptions of Tables and Books. Upon request, the chairman of the editorial committee will supply copies of any table for a nominal cost per page.

Subscriptions, address changes, business communications and payments should be sent to:

American Mathematical Society
P. O. Box 6248

Providence, Rhode Island 02904

## Take the mystery out of list processing with BRILLINGER and COHEN's-

 Introduction to Data Structures and Non-Numeric Computation (with WATFOR and WATFIV)

PETER C. BRILLINGER, University of Waterloo, and DORON J. COHEN, Technion-Israel Institute of Technology Computer Center.
A comprehensive discussion of data representations and data structures-this new book considers in detail operations and applications with character strings, linearly linked lists, graphs and trees. It offers an in-depth study of list processing techniques that teaches the basic algorithms usually used by high-level list processing languages. The authors explain programming language translation, including syntax analysis, object-code generation, and macro processors. Introduction to Data Structures and Non-Numeric Computation (with WATFOR and WATFIV) explores details of real-life systems such as car rental transactions, symbolic manipulation of expressions, and organization of index terms for a book. Elaborate explanations and fully coded examples provide for self-study, and emphasis is placed on mechanics rather than theory. The authors stress method and internal representations rather than the language itself. The text provides ample problems, exercises, and illustrations of examples to tacilitate learning. 1972629 pp. $6 \times 9$ cloth ( $013-479899.6$ ) $\$ 12.00$


## erative

.....that you add IMP to your reference library. The INDEX OF MATHEMATICAL PAPERS is a publication which appears every six months, providing readers with 4,000 to 5,000 bibliographic references per issue. This publication indexes titles both by author(s) and by subject classification. It now covers more than half the journals now reviewed in full by MATHEMATICAL REVIEWS; and deals with all areas of pure mathematics; topics in applied mathematics and mathematical physics; and mathematical applications in other physical, biological, and social sciences.

ORDER FORM - INDEX OF MATHEMATICAL PAPERS

| Volume and Issue | Period Covered | Publication Date | Price per Copy | Quantity Ordered | Total Price |
| :---: | :---: | :---: | :---: | :---: | :---: |
| Volume 1 | July - December 1970 | July 1972 | \$30 |  | \$ |
| Volume 2, Issue 1 | January -June 1971 | November 1972 | \$30 |  | \$ |
| Volume 2, Issue 2 | July-December 1971 | January 1973 | \$30 |  | \$ |
| Volume 3, Issue 1 | January--June 1972 | April 1973 | \$40 |  | \$ |
| Volume 3, Issue 2 | July - December 1972 | April 1973 | \$40 | - | \$ |Payment enclosed \$ $\qquad$ Date $\qquad$

$\square$ Please billPlease enter my standing order for $\qquad$ copy (ies), to begin with Volume $\qquad$ -.
$\square$ Please send information on the magnetic tape edition of the Index.

Send bill to $\qquad$
$\qquad$
$\qquad$
Ship to $\qquad$
$\qquad$
$\qquad$


Professor Arthur J. Bernstein, Computer Science Department, State University of New York.
Professor Henry D. Block, Department of Theoretical and Applied Mathematics, Cornell University.
Professor W. Morven Gentleman, Faculty of Mathematics, Department of Applied Analysis and Computer Science, University of Waterloo.
Dr. R. L. Graham, Bell Laboratories.
Professor Juris Hartmanis, Department of Computer Science, Cornell University.
Professor John E. Hopcroft, Computer Science Department, Cornell University.
Professor Richard Karp, Computer Science Department, University of California, Berkeley.
Professor Eugene Lawler, Department of Electrical Engineering and Computer Science, University of California, Berkeley.
Professor C. L. Liu, Department of Computer Science, University of Illinois.
Professor J. T. Schwartz, Courant Inst. of Math. Sciences, New York University.
Dr. Richard E. Stearns, General Electric Research and Development Center.

## SEND ORDERS TO SIAM PUBLICATIONS

33 S. 17th Street, Phila., Pa. 19103
PLEASE NOTE:
All orders from Japan should be sent to our exclusive agent: U. S.-ASIATIC COMPANY, LTD., Tsutsumi BIdg. 13-12 1-chome, Shimbashi Minato-ku, Tokyo, Japan.
\$3200
per volume (4 issues) add $\$ 5.00$ per volume for overseas orders.

SIAM Members:
\$2400
Bounds on Iterated Coerror Functions and Their Ratios ..... 413
An Asymptotic Expansion of $W_{k, m}(z)$ with Large Variable and Parameters R. Wong ..... 429
Reviews and Descriptions of Tables and Books ..... 437
Agrest \& Maksimov 21, Brousseau, Editor 24, Chan, Chan \& Mead 23, Duvaut \& Lions 15, Ekman \& Fröberg 26, Fettis \& Caslin 22, Frevel 16, Frevel \& Blumer 17, Hochstadt 20, Luke 13, Maurer 27, Miller 25, Slaviф 18, Slavic 19, Stroud 14.
Table Errata ..... 451
Choong, Daykin \& Rathbone 501, Erdélyi, Magnus, Oberhettinger \& Tricomi 502, Gradshteyn \& Ryzhik 503.
Corrigendum ..... 453
Kravitz \& Madachy

## Information for Contributors

Manuscripts should be typewritten double-spaced in the format used by the journal. For journal abbreviations, see the latest Mathematical Reviews volume index. An author should submit the original and one copy of the manuscript and retain one copy. The author may suggest an appropriate editor for his paper. It is recommended that the author acquaint himself with the pertinent material contained in "Information for Contributors to Mathematics of Computation" and "Manual for Authors," both of which are available upon request from the American Mathematical Society. All contributions intended for publication and all books for review should be addressed to Eugene Isaacson, Chairman, Editorial Committee, Mathematics of Computation, New York University, Courant Institute of Mathematical Sciences, 251 Mercer Street, New York, New York 10012. Institutions sponsoring research reported in the journal are assessed page and microfiche charges.

Each article submitted for publication must be accompanied by a brief and reasonably self-contained abstract, and by AMS (MOS) subject classification numbers. If a list of key words and phrases is included, it will be printed as a footnote on the first page. A list of the classification numbers may be found in the Index to Mathematical Reviews, Volume 39 (June 1970).

## Microcard Edition

Volumes 1-14 (1943-1960) are available on Microcards at $\$ 39.00$ for the complete set and may be purchased from Microcard Editions, Inc., 901 26th Street, N. W., Washington, D.C. 20037.

# Mathematics of Computation 

## TABLE OF CONTENTS

APRIL 1973
The Finite Element Method with Penalty Ivo Babuška ..... 221
Simplified Proofs of Error Estimates for the Least Squares Method for Dirichlet's Problem Garth A. Baker ..... 229
On the Numerical Computation of Parabolic Problems for Preceding Times B. L. Buzbee \& Alfred Carasso ..... 237
A Modified Butcher Formula for Integration of Stiff Systems of Ordinary Differential Equations H. Nosrati ..... 267
The Euler-Maclaurin Expansion for the Simplex J. N. Lyness \& K. K. Puri ..... 273
Asymptotic Expansions for Product Integration
Frank de Hoog \& Richard Weiss ..... 295
Note on Error Bounds for Numerical Integration J. H. Hetherington ..... 307
On a Method of Carasso and Laurent for Constructing Interpolating Splines M. J. Munteanu \& L. L. Schumaker ..... 317
Chebyshev Approximation by Exponentials on Finite Subsets
Dietrich Braess ..... 327
A Winding Number Algorithm for Closed Polygonal Paths . . J. V. Petty ..... 333
Iteration Methods for Finding all Zeros of a Polynomial Simultaneously Oliver Aberth ..... 339
On Computing Some Extremal Periodic Positive-Definite Functions R. L. Page ..... 345
An Error Analysis of a Method for Solving Matrix Equations C. C. Paige ..... 355
On Computing the Minimal Number of Defining Relations for Finite Groups T. W. Sag \& J. W. Wamsley ..... 361
An Algorithm for Generating the Sphere Coordinates in a Three-Dimensional Osculatory Packing David W. Boyd ..... 369
Calculation of the Ramanujan $r$-Dirichlet Series Robert Spira ..... 379
On the Vanishing of the Iwasawa Invariant $\mu_{p}$ for $p<8000$ Wells Johnson ..... 387
Three Thirteens L. J. Lander ..... 397
On the Gaussian Primes on the Line $\operatorname{Im}(X)=1$ M. C. Wunderlich ..... 399
Complex Zeros of the Error Function and of the Complementary Error Function Henry E. Fettis, James C. Caslin \& Kenneth R. Cramer ..... 401
Saddle Point of the Complementary Error Function
Henry E. Fettis, James C. Caslin \& Kenneth R. Cramer ..... 409

